INTERNATIONAL CASE STUDIES AND NATIONAL PHOTOVOLTAIC DISSEMINATION PROGRAMS: A FEW QUESTIONS FOR THE FUTURE OF THE BUILDING INTEGRATION OF PHOTOVOLTAICS.

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Abstract. Years ago when we started writing about photovoltaics (PV), our goal was to convince people in the building sector to use photovoltaic modules as a building component. Today, the large number of buildings using photovoltaic modules demonstrate that PV has become an important construction material for those projects that wish to address the issue of environmental quality and to stay abreast of the rapid evolution of building technology.

What is left to say about the architectural integration of photovoltaic? What should research in this field next address? What kind of PV components should be introduced at the national level, more than just as an international product, that could help to face the growing distribution of the photovoltaic in so many different countries? How should PV eventually tackle the finite amount of building space?

This paper wishes to raise questions that aim at comparing the potential of photovoltaic material to conventional construction materials, and to suggest the possible steps needed to overcome the barrier of acceptance of PV in different urban contexts, different historic centres and different cultures. Some international case studies, collected by the colleagues of Task VII of the International Energy Agency, and other examples, will be briefly discussed to analyse different construction markets and to identify appropriate design strategies. The lessons learned during the realisation and from the impact of so many PV buildings should be brought to bear on the possible success or failure of both our future Italian 10,000 roofs program and the other international programs soon to follow.

1. INTRODUCTION

The last decade has witnessed the spread of many significant international programs for the dissemination of photovoltaic in both urban and rural contexts. These programs have been extremely important not only for the visibility and publicity given to this material, but also for the stimulus given to photovoltaic manufacturing and research. These programs have been able to obtain the electrical energy companies cooperation with the building industry. Innovative components have been studied and employed to meet the evolving technological needs of buildings. The first applications proposed were often photovoltaic integration to existing edifices. The modules used were those initially developed for agricultural operations or for electrical generating systems. The results not only horrified the clients and the architects, but even a few electrical engineers. Nevertheless, these initial experiments were important insofar as they forced architects and engineers to perform complex "exercises of style," in order to integrate traditional photovoltaic modules in the best possible manner. This was before the photovoltaic industry was convinced of the need to produce modules truly worthy of being integrated.

2. DIFFICULT PV PRODUCTS

Today there is a market for building integration while photovoltaic products for the construction industry are still far too few and far from versatile. Frequently, an architect's request to change dimensions, frames, fastening details or the colour of a module results in such added costs and lengthy delivery times as to force the utilization of the available product in the least offensive way possible. Photovoltaics, therefore, are not as flexible as other facing materials. This is obviously due to the inherent complexity in using these panels not only as a building skin but also as a means of generating electricity from solar radiation.

Before making the decision to utilize photovoltaic panels, rather than stone or any other conventional materials, we must consider the orientation of the structure, possible shadow effects, the correct inclination of the panels, the morphology of the volume of the edifice, the sum of available surface, and the amount of electrical energy that needs to be generated.

Fig: 1 Amersfoort, NL. View of housing with standard PV modules**.**

Perhaps the best example of how these competing requirements can be met is found in the Amersfoort project in Utrecht, Holland. This is one of the most extensive use of photovoltaic technology ever integrated with a residential complex.

A new suburb of five hundred and one houses, of a traditional Dutch housing typology, have been covered with photovoltaic panels that produce approximately 1.3 million kilowatts, which is fifty-four percent of the electrical energy required.

What is striking in such a successful example as this are both the architectural qualities of the individual houses and the urban planning skills necessary to coordinate such an undertaking. Entire streets and waterways were re-oriented so as to position the photovoltaic panels. PV has not only influenced the traditional layout within the residences, but has also altered the symmetry typical of Dutch streets, to render the sufficient number of southern exposures.

"*To create a serene and closed residential area, symmetric streets are often felt necessary. However, orientations towards the sun introduces asymmetrical aspects. Various projects illustrate how this contradiction can be solved, with skylights or open-plan areas that let in lots of daylight... Solar panels are new and fairly noticeable and therefore gain a lot of attention. To create a uniform look for the area it is important to have an urban plan that takes into account the various roof shapes and colours.*"[1]

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[1] Bouwmeester and Van Ijken 1999, *Bouwen op de zon. Nieuland, Amersfoort.Eindeloze energie in een duurzame wijk.* p.91. REMU NV, Utrecht.

Most of these houses are covered with traditional photovoltaic modules. The choice of this material has effected changes in planning, construction and the installation of roof insulation. The end result, however, is an outstanding integration of common industrial modules. One of the greatest difficulties to overcome is the discrepancy between the size of the available panels and the standardised dimensions typical of the construction industry. The modules customarily produced by the manufacturers should conform to the measurements used for prefabricated building materials. The collaboration between architects, designers and the photovoltaic industry is still slow and halting, despite our wish to believe that the opposite is true.

I have always emphasised the importance of identifying design solutions that could be replicated by the producers of photovoltaic panels in my other writings. New photovoltaic components must be among the offerings for the construction trades. My enthusiastic regard for the potential that photovoltaics has as a building material for the future is consistent with current trends. Buildings are increasingly becoming a sort of industrial product, at times almost monumental mannerist machines of glass and steel, as exemplified by the work of Renzo Piano or Sir Norman Foster's dome for the new German Federal Parliament in Berlin.

What will be the fate of these buildings in the next fifty years? It may well be expedient to demolish them and build them anew. Photovoltaics would clearly gain an advantage in this case, since the technology will surely have reached such levels of efficiency and versatility as to make the existing systems out-of-date. I do not mean, however, that photovoltaics will be an obsolete technology, but rather that forecasts are required to see what investments will be needed in this sector. What will be the costs of conforming to technical norms in constant revision? What will this entail when it is necessary to replace these roofs or façades?

Another question must be raised regarding the architectural integration of photovoltaic technology. What will be the role of photovoltaics when the new construction market has been exhausted, when the lack of space ends the raising of new buildings? This question seems absurd at first glance. The future is too unpredictable to look that far in advance, neither is it possible to anticipate what the products of the research in this field will be. Yet when this question is framed in terms of the historic centres of many European cities, particularly in Italy, it immediately becomes not a question for the future, but one to be answered today.

Fig. 2: Japan. Houoh High School. NEDO commercial roofing tiles

How can photovoltaics be compatible with the restoration or maintenance of historic buildings?
Does it make any sense to attempt to design photovoltaic roof tiles to set next to the traditional ones, when this hybrid mélange of the two materials is so unsatisfactory from an aesthetic point of view?

It is useless to deceive ourselves that photovoltaic materials can replace conventional electrical systems in the historic centres of Italy except when carefully installed on flat roofs that are not seen from the streets.

As far as roof tiles are concerned, it is best to study alternative solutions for covering newer buildings rather than substituting portions of old terracotta tiles and building façades. In Japan, however, the heritage of traditional Japanese architecture, with its pagoda-like roofs, has been integrated with photovoltaic roof tiles designed to meet this particular need. These modules have completely replaced the conventional tiles, rather than only a portion of them, which obviously helps to avoid that discouraging compromise of a hybrid collage.

3. PV AND THE CONSTRUCTION MARKETS

It is common knowledge that the construction market is closely connected to the larger economic one. It is not surprising that the most satisfactory examples of the architectural integration of photovoltaic materials have been achieved in Japan, the United States, Switzerland, Germany and Great Britain. Many of these projects demonstrate how photovoltaic technology has kept abreast of iron and steel technologies, as some of the following Task VII case studies show.

In New York the 4T skyscraper in Times Square was designed by Fox and Fowle Architects in collaboration with Gregory Kiss. The 15 kWp monocrystalline thin film technology is so well integrated that it is difficult to distinguish it from the rest of the traditional curtain wall.

In California the architect Steven Strong has created playful constructions of large photovoltaic sculptures, such as the Discovery Centre Solar Cube or the Solar Electric Sunflowers, after years of intense and serious commitment to developing this technology.

Fig. 3: Great Britain. Doxford Solar Office. 73 kWp of PV facade integration

David Lloyd Jones in Great Britain’s Doxford Solar Office has achieved impressive results of the correct architectural integration of photovoltaic materials. Not only does the aesthetic valence generate 73 kWp, but the photovoltaic system integrated in the façade also takes advantage of passive solar energy to heat the building.

Photovoltaic technology in all of these cases has followed the architectural trend toward stylistic internationalisation. There is no doubt that this is the right approach, but is there any photovoltaic product that has been studied for vernacular architecture? Is it possible to do so? I frankly think it is almost impossible, and I would like to urge those companies that are struggling to produce roofing tiles that are imitations of the traditional ones to stop trying. The results are often counterproductive since they discourage potential clients with good taste.

I would like to take this opportunity to solicit PV manufacturers and designers to start thinking of appropriately designed street lamps, canopies, kiosks or any public urban object to be introduced in the countryside, suburbs, or even in third world countries. Please forbid the installation of horrible metal sticks with PV modules hooked on them and called streetlights. The primary necessity of bringing electricity where is needed, cannot justify the spread of the worst examples of PV objects. This not only is counterproductive to the acceptance of PV, but makes a negative impact on vernacular villages and unsullied landscapes.

Let us not forget that the acceptance of PV, in most cases depends on the aesthetic quality of the material, and not on mature environmental awareness.

4. RECOMENDATIONS FOR THE ITALIAN PV PROGRAM

It would be responsible to point out to the new photovoltaic programs in Italy and in all other countries with a rich architectural legacy, and with powerful landmark commissioners, that the real market for photovoltaics may be found in the environmental improvement on the outskirts of the cities, in the reuse of abandoned industrial areas and in urban furnishings.

In Italy where there is so little new construction and so much renovation, photovoltaic components must be nearly invisibly positioned in the existing structures. The market is conversely larger for photovoltaic urban furnishings that are needed to improve coastal areas and to be set in archeological parks where lighting is needed, but where it is practically impossible to excavate and bury electric cables.

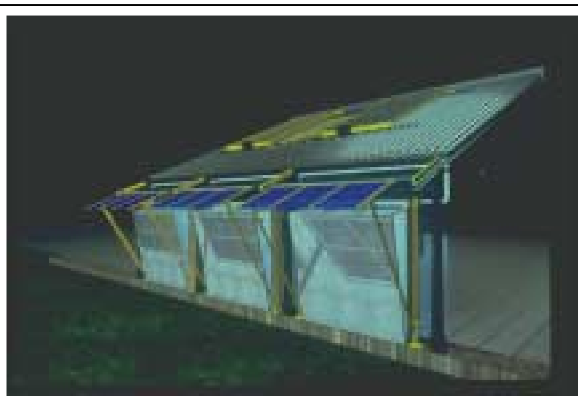

Fig. 4: Italy. Children's Museum of Rome. 15kWp integrated in roof and canopy of an old industrial building.

Most Italian photovoltaic projects have remained on the drawing boards. They are often excellent ideas that were unable to find sufficient financing due to the innately dysfunctional economics of the construction industry. This, along with our characteristic political instability and high labor costs, does little to encourage foreign investors.

A great deal of work is needed to persuade Italians to adopt photovoltaic technology, a problem that Italy shares with the rest of the world. It may be worth trying to convince people that having a photovoltaic system is irresistibly chic.

Let us make photovoltaics a status symbol much as a Rolex, a Ferrari and other beautifully designed objects are.

In Italy, which has one of the highest numbers of cellular telephones and Smart cars per capita, making photovoltaics fashionable may well be the most effective strategy. An ambitious five-year program for installing 10,000 photovoltaic roofs has been launched by ENEA, under the aegis of the Italian ministries of the environment and industry. This has yet to commence. The goal is to install approximately 8,900 1-5kWp systems and 1,100 5-50 kWp systems, for a total capacity of 50 MWp. Italy is famous for high quality industrial design, and I am certain that this target will be met, if the problem is posed in the appropriate terms and objectives.

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